

# MECHANISTIC STUDIES OF PHOTOTHERMAL AGING

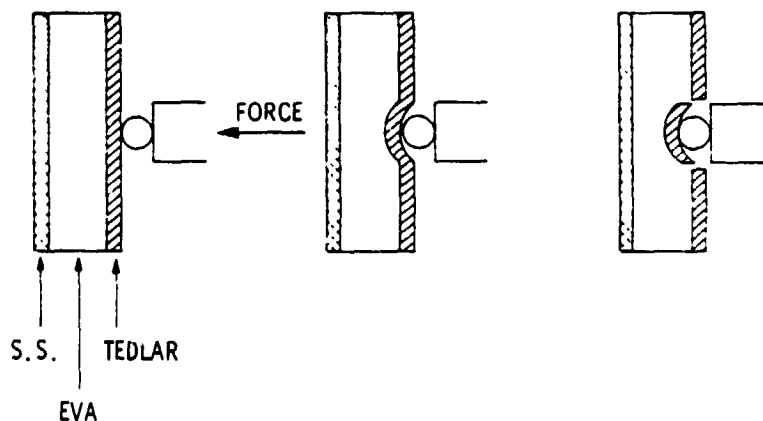
JET PROPULSION LABORATORY

R. H. Liang

## Objective and Approaches

- OBJECTIVE
  - TO DEVELOP METHODOLOGY WHICH IS CAPABLE OF PREDICTING LONG-TERM BEHAVIOR OF POLYMERIC MATERIALS FOR OUTDOOR APPLICATIONS
- APPROACH
  - TO UNDERSTAND MECHANISMS OF DEGRADATION
  - TO DEVELOP VALID ACCELERATED TESTING FOR MATERIAL EVALUATION

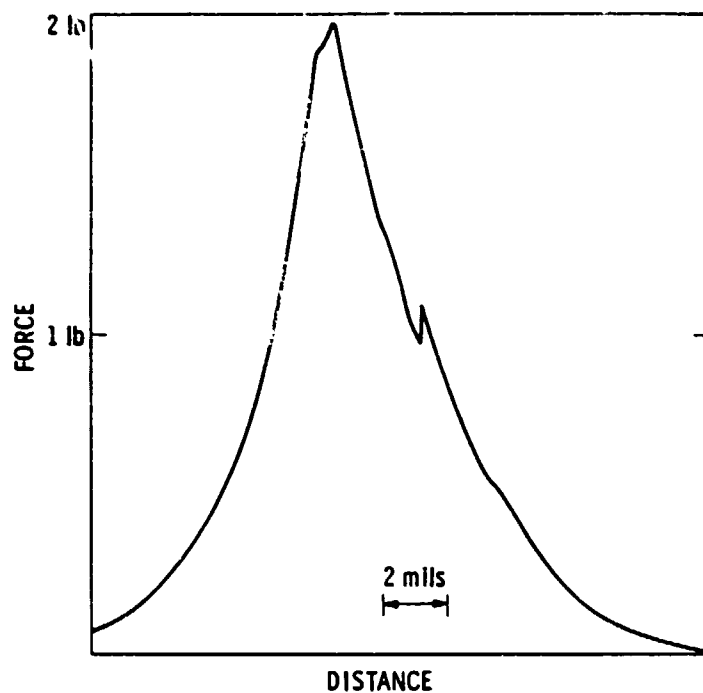
## Compression Testing of Tedlar/EVA/Stainless Steel Module



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## RELIABILITY PHYSICS

### Compression Test of Outdoor Aged (500 Days) Tedlar/EVA/Stainless Steel Module

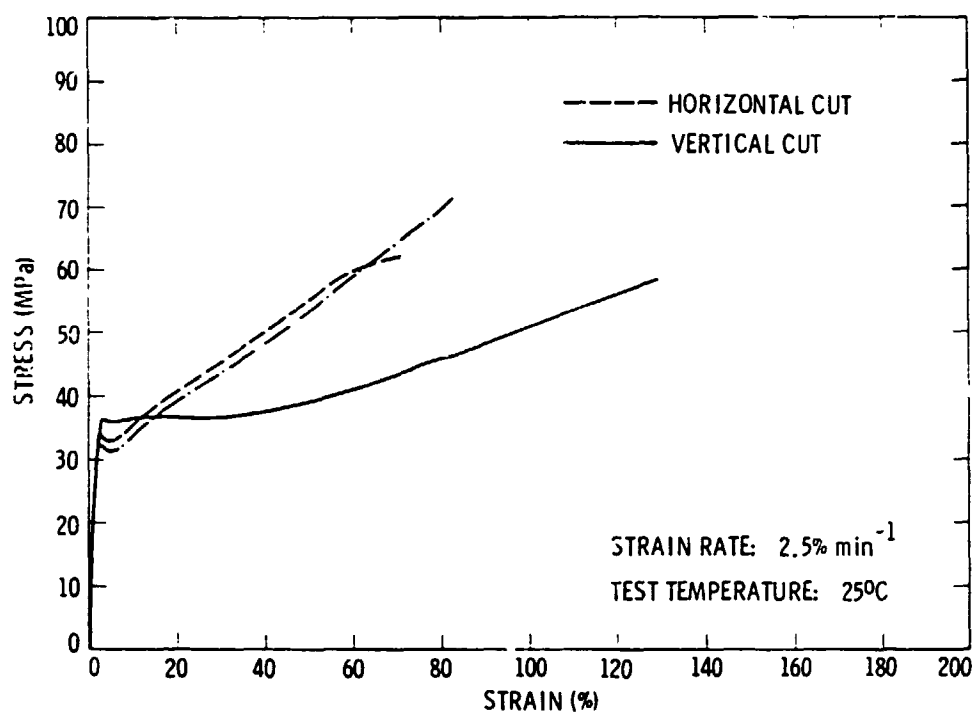


### Compression Testing of Tedlar/EVA/Stainless Steel Module

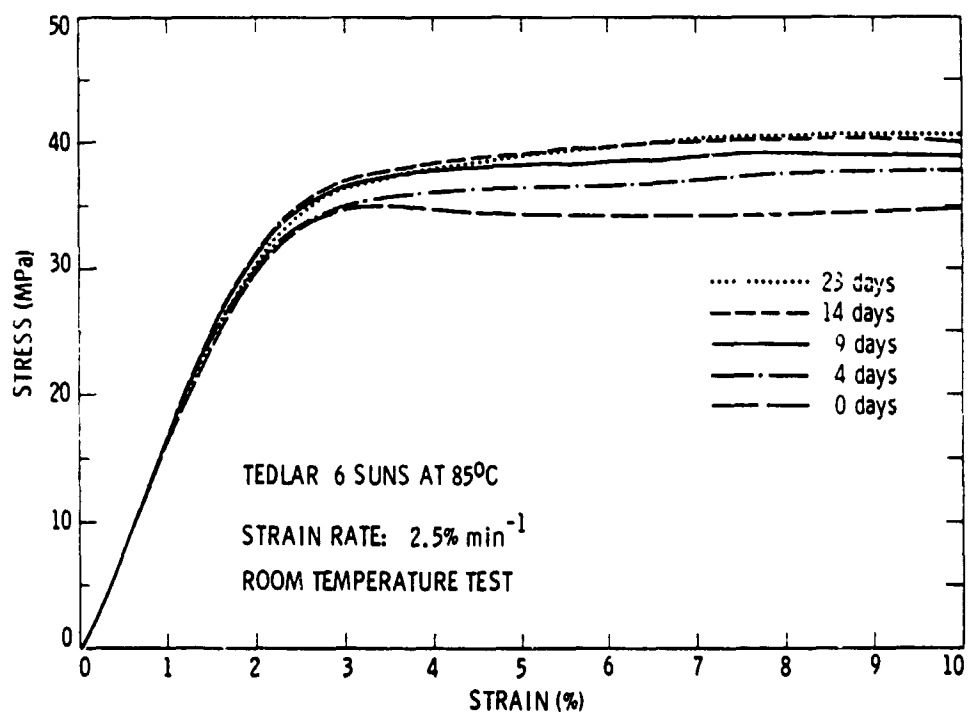
SAMPLE	FORCE AT BREAK (lb)
CONTROL	31
OUTDOOR (500 days)	1.2
85°C, 8 SUNS (6.5 days)	1.0
98°C, 5.5 SUNS (6.5 days)	DID NOT BREAK

## RELIABILITY PHYSICS

### Tedlar Controls (As Received)

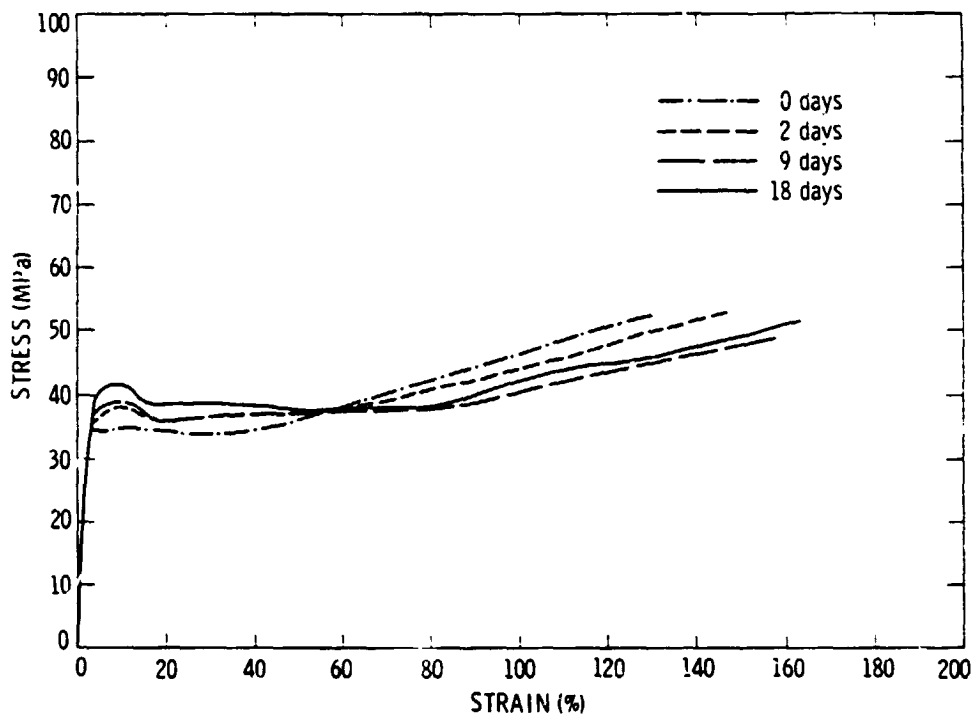


### Stress-Strain as a Function of Exposure Time (Days)

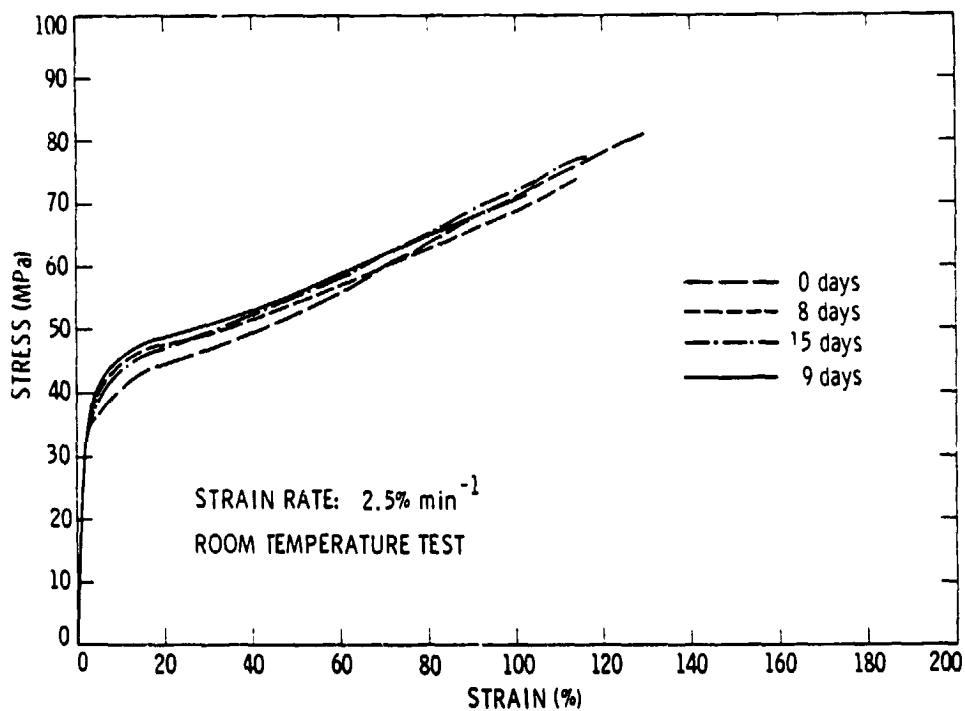


## RELIABILITY PHYSICS

### Stress-Strain Curve of Tedlar Aged at 6 Suns and 85°C



### Stress-Strain Curve of Laminated Tedlar Aged at 6 Suns and 85°C



## RELIABILITY PHYSICS

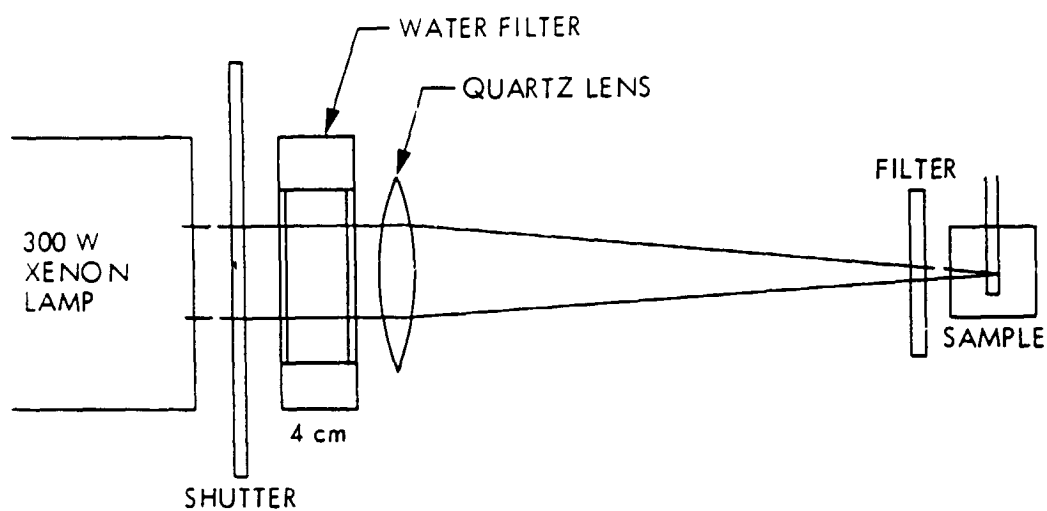
### Conclusions for Tedlar Studies

- TEDLAR DAMAGE IS CHIEFLY UV DRIVEN
- QUAL TEST TEMPERATURE SHOULD BE  $\leq 85^{\circ}\text{C}$
- DIAGNOSTIC TECHNIQUE HAS BEEN DEVELOPED
- SYNERGISTIC EFFECT OF TEDLAR AND EVA IS BEING EVALUATED

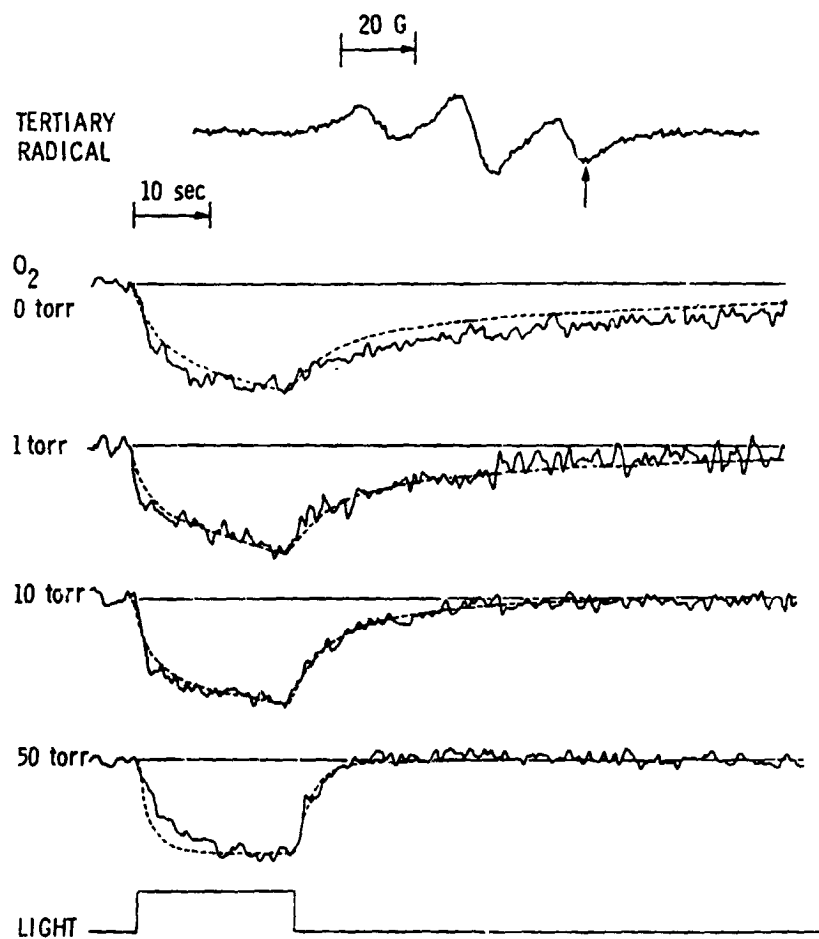
### Mechanistic Studies of Photothermal Degradation

- OBJECTIVE
  - TO STUDY MECHANISTIC PATHWAYS OF PHOTOTHERMAL DEGRADATION
  - TO DETERMINE DEGRADATIVE REACTION RATES FOR MOLECULAR MODELING
- APPROACH
  - IDENTIFY FAILURE MODES
  - DETERMINE DEGRADATION MECHANISM
  - DEVELOP ACCELERATING CRITERIA
  - DEVELOP ACCELERATING METHODOLOGY
  - DEVELOP DIAGNOSTIC TECHNIQUES

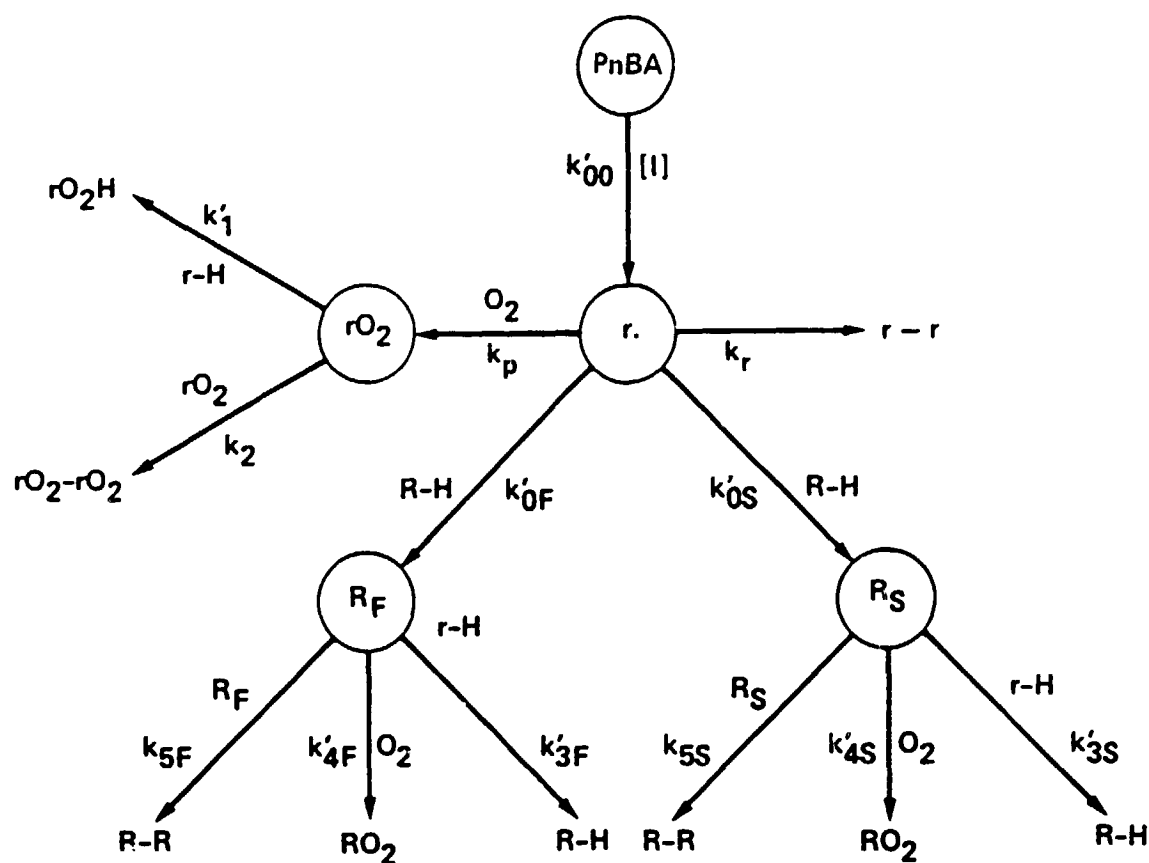
# Flash Electron Spin Resonance Apparatus



# Kinetic Studies of Photogenerated Tertiary Radical at Various Oxygen Pressures



Mechanism of Photooxidation of Poly-n-Butyl Acrylate





# RELIABILITY PHYSICS

## Kinetic Parameters of Poly-n-Butyl Acrylate Photooxidation

RADICAL	RATE CONSTANTS (25°C)
INTERMEDIATE	$k_p' = 700 \text{ l m}^{-1} \text{ s}^{-1}$ $k_r = 8 \times 10^5 \text{ l m}^{-1} \text{ s}^{-1}$
TERTIARY	$k_{OF} = 5 \times 10^{-1} \text{ s}^{-1}$ $k_{OS} = 1 \times 10^{-1} \text{ s}^{-1}$ $k_{3F}' = 1.3 \times 10^{-1} \text{ s}^{-1}$ $k_{3S}' = 8 \times 10^{-3} \text{ s}^{-1}$ $k_{4F}' = 700 \text{ l m}^{-1} \text{ s}^{-1}$ $k_{4S}' = 300 \text{ l m}^{-1} \text{ s}^{-1}$ $k_{5F} = 5 \times 10^4 \text{ l m}^{-1} \text{ s}^{-1}$ $k_{5S} = 3 \times 10^3 \text{ l m}^{-1} \text{ s}^{-1}$
PEROXY	$k_i' = 2 \times 10^{-2} \text{ s}^{-1}$ $k_2 = 5 \times 10^4 \text{ l m}^{-1} \text{ s}^{-1}$